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Does Urban Proximity Enhance Technical Efficiency in Agriculture? Evidence from China

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Résumé / abstract

Despite strong productivity gains since the beginning of the reforms, Chinese agriculture still suffers from a low level of technical efficiency. This article studies whether or not urban proximity stimulates technical efficiency. More specifically, we ask two questions. Are counties close to cities more efficient than remote ones? Do different cities exert different impacts? The empirical examination is carried out at the county-level in three provinces of China. According to our results, the closer a county is to a city, the more efficient it is. In addition, the best situation would be to be close to a small and not too heavily industrialized city.

Mots clés /Key words : Agriculture, technical efficiency, urban proximity, stochastic frontier model, China
Codes JEL / JEL codes : O13, O18, Q10, R11

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1. Introduction

Agricultural productivity growth is a real challenge for China today. On the one hand, given the increase in food demand and the growing shortage in arable land[1], agricultural productivity growth is the only solution to avoid importing large quantities of food. On the other hand, although non-agricultural activities represent a growing share of rural households' income, agriculture remains a major source of income for them. Then, to reduce poverty and inequalities between rural and urban areas, there is a need to raise agricultural productivity (Liu and Zhang, 2000). Finally, because of intersectoral linkages, agricultural growth has a positive effect on the development of non-agricultural activities (Haggblade, Hazell and Reardon, 2002). Thus, agricultural productivity is both important in terms of alimentary self-sufficiency, poverty reduction and economic development. That is why, many papers try to disentangle the determinants of agricultural productivity in China. For instance, the effect of infrastructures (Fan and Zhang, 2004), migration (Taylor, Rozelle and de Brauw, 2003) and environmental degradations (Rozelle, Veeck and Huang, 1997) have been investigated.

An interesting fact in China is that all the components of agricultural productivity have not experienced the same evolution[2] (Kalirajan, Obwona and Zhao, 1996; Mao and Koo, 1997; Chen et al., 2008). Actually, technical change is the strength of agriculture as it contributes the most to total factor productivity (TFP) growth. On the contrary, technical efficiency[3] is the weakness of Chinese agriculture as it is both low and decreasing and, therefore, negatively contributing to TFP growth. As a result, many papers study its determinants (Fan, 1991; Lin, 1992; Brümmer, Glauben and Lu, 2006; Chen, Huffman

[1]Between 2001 and 2008, although population increased by 4% and per capita income doubled, cultivated area fell by nearly 6.5%. Moreover, before that, the arable land area in China was already far below the world average as it was only 0.11 hectare per capita in 2000 (Tan et al., 2005)

[2]Changes in total factor productivity can be broken down into technical change and efficiency change (Coelli et al., 2005).

[3]Technical efficiency measures the ability to produce the maximum output which can be produced given the inputs and the technology. A producer is considered as technically inefficient if its effective production level is lower than the maximum output it could produce.

and Rozelle, 2009; Monchuck, Chen and Bonaparte, 2010).

Although many determinants of agricultural efficiency have been investigated, very little attention has been dedicated to the study of urban proximity. However, urban development has, for a long time, been recognized as a major solution to the low level of agricultural productivity (Nicholls, 1961). More precisely, agricultural productivity and rural development would be higher in rural areas close to urban agglomerations ("Urban-industrial hypothesis" (Schultz, 1951)). Only a few studies examine whether or not urban proximity fosters development in rural areas[4] in China and no consensus exists. For example, Fan, Chan-Kang and Mukherjee (2005) estimate that urban growth does not contribute to reduce rural poverty in China. Moreover, according to Peng, Zucker and Darby (1997), if cities often have a positive effect on the development of rural industry, the agricultural sector would suffer from urban proximity. To our knowledge, only Benziger (1996) and Ma et al. (2007) empirically analyze the effect of urban proximity on agricultural productivity in China. The two studies conclude than urban proximity has a positive impact on agricultural productivity and more particularly, on technical change. However, none of these works assess the effect of urban proximity on technical efficiency.

Therefore, there is a serious need to assess if cities affect the agricultural efficiency of their neighboring rural areas in China. This question has important policy implications. First, there are still strong restrictions[5] between rural and urban areas in China where some parts of the countryside still remain tremendously remote. The evidence of positive spillovers of cities on rural areas could contribute to reduce these restrictions. Secondly, in terms of urban planning, it is also important to assess whether or not different cities have different impacts. Indeed, whether the optimal policy consists in promoting the development of some large cities or in focusing on the development of small and medium-

[4]Following Benziger (1996) and Peng, Zucker and Darby (1997), we carry out an analysis at the county-level which is the third level of administrative divisions in China. Therefore, rural areas refer to counties (*xiàn*) and urban areas to county-level cities (*xiànjishì*) or to urban districts (*shìxiaqu*) under prefectoral (*dìjíshì*) or provincial (*zhíxiáshì*) level cities.

[5]These restrictions mainly take the form of administrative barriers with the Household Registration System, or *hukou*, but the lack of infrastructures also play a significant role.

sized cities is still an open question in China[6]. Finally, the existence (or absence) of ties between cities and their neighboring rural areas could influence the type of policies implemented. As Roberts (2000) underlines, where ties between rural and urban areas are strong, a global development policy, encompassing both rural and urban areas, would be optimal. On the contrary, where ties are weak, a rural-focused development policy would be preferable.

We contribute to the literature in two ways. First, we propose a theoretical framework in which we disentangle the different channels by which urban proximity can affect technical efficiency in agriculture. Our second contribution is to empirically assess whether or not cities affect the technical efficiency level of their neighboring rural areas. To do so, we estimate the model for inefficiency effects in a stochastic frontier production function (Battese and Coelli, 1995). Several measures of urban proximity are used to ensure the robustness of the results. Our analysis concludes that cities positively affect the level of technical efficiency of their neighboring rural areas. In addition, different kinds of cities, in terms of size and economic structure, would have different impacts.

The remainder of this paper proceeds as follows. Section 2 is a theoretical analysis which identifies the main channels by which urban proximity can affect technical efficiency in the agricultural sector. Section 3 presents the data and Section 4 the methodology. Econometric results are analyzed in Section 5. Section 6 concludes and presents some policy recommendations.

2. Theoretical analysis: urban proximity and agricultural technical efficiency

First of all, proximity to a city offers farmers opportunities to become rich which encourages them to provide more labor effort. Major agricultural reforms have been implemented since 1978 in China. As they give the opportunity for farmers to become rich and reward individual efforts, they have led to important productivity gains in agriculture (Fan, 1991; Lin, 1992). Yet, market access determines whether or not farmers can enjoy

[6]For a description of the successive urbanization strategies implemented in China, see Kamal-Chaoui, Leman and Rufei (2009).

these enrichment opportunities (Benziger, 1996). Indeed, farmers close to cities can sell their produce, especially economic crops, on the urban market. On the contrary, the more remote households are forced into self-consumption agriculture as there is no market where they can sell their production. Moreover, the closer the farmers are to the city, the lower the transport costs they have to bear and thus, the higher the sale prices are for their products. As a consequence, farmers close to cities are encouraged to be more efficient.

Secondly, peri-urban areas suffer from losses in arable land which are converted for urban uses. For example, in Beijing, Tianjin and Hebei's region, urban area rose by 71% between 1990 and 2000. And, among the new areas converted for urban uses, 74% were farmlands. In this context of high competition between the different uses of land, the only parcels which will not be converted for urban uses are the ones where agricultural yields are high (Livanis et al., 2006). Given the lack of respect for leases in rural China, there is a high risk for inefficient farmers close to cities of being expropriated[7]. The fear of being relocated could force farmers close to cities to intensify their labor effort.

In addition, cities are information centers where new ideas emerge. Rural areas close to cities benefit from the diffusion of knowledge and ideas which enables them to better control their environment and new technologies *i.e.* to be more efficient (Jacobs, 1969).

Finally, rural workers close to cities have a higher probability of working out of the agricultural sector (Knight and Song, 2003). Indeed, in suburban areas, rural workers benefit from more job opportunities both in rural industries, which are concentrated around cities (Peng, Zucker and Darby, 1997), and directly in cities, through commuting. This could have two opposite effects on technical efficiency. On the one hand, this enables to reduce the huge surplus of agricultural labor which should lead to an increase in labor efficiency

[7]In China, there is still a lack of respect for leases of farmland. Indeed, farmers have leases which give them the right to use their land but the land ownership remains collective. As a result, the local authorities decide what to do with the land even if farmland is under lease. Thus, sometimes, local authorities relocate farmers in order to obtain their farmland to turn it over to non-agricultural uses which are more lucrative (Naughton, 2007). Given the very high competition for non-agricultural jobs in rural China and the low skills of most farmers, there is a high risk for them to become under or unemployed after having lost their land (Kamal-Chaoui, Leman and Rufei, 2009).

(Lewis effect). However, areas close to cities could also suffer from backwash effects if the most efficient workers, typically young and educated men, leave agriculture to work in more remunerative and socially rewarding activities. All the transmission channels through which cities can affect the agricultural technical efficiency of neighboring rural areas are summarized in Table 1. *A priori*, the effect of urban proximity on agricultural efficiency is ambiguous.

[Table 1 here]

If urban proximity is likely to affect efficiency, in addition, we expect different kinds of cities, in terms of size and economic structure, to have different impacts on rural areas. Indeed, farmers close to big cities benefit from more opportunities to sell their production which should spur efficiency. However, bigger cities also offer more employment opportunities out of agriculture which can either have a positive (reducing labor surplus) or a negative ("stealing" the most efficient workers) impact on efficiency. If the city size is likely to matter, the economic structure should also have an impact. Indeed, cities in which the agricultural sector is still important[8] are likely to offer few opportunities to neighboring farmers to sell their production. However, farmers could benefit from more knowledge spillovers if the economic structure of the city is similar to that of the rural area. Finally, rural workers close to industrial cites benefit from more jobs opportunities out of agriculture which could reduce the labor surplus but also drain rural areas from their most efficient workers.

3. Data

3.1. Sample

Following Benziger (1996) and Peng, Zucker and Darby (1997), we use county-level data to study the effect of cities on rural areas in China. Our sample consists of 117 counties belonging to three provinces of East China : Anhui, Zhejiang, and Jiangsu over

[8] In China, county-level cities have an economic structure very similar to counties as they still rely heavily on agriculture.

the period 2002-2007[9]. The limited availability of indicators at the county-level leads us to study these three provinces which have published the necessary indicators over quite a long period. The dataset on counties is from the Provincial Statistical Yearbooks (2003-2008) and from the China Statistical Yearbook for Regional Economy (2003). One advantage of this period of time is that very few administrative changes occured, which enables us to avoid suffering from "reclassification bias" unlike former studies[10] (Gu et al., 2001 for example). In addition, one advantage of working on these three provinces is that they share similar characteristics in terms of geography, climate and cultural conditions (Fan, 1991). Relating to urbanization, Jiangsu and Zhejiang are to a large extent above the national average with urbanization rates of 53.2% and 57.2% respectively compared with 44.94% for China as a whole in 2007[11]. These two coastal provinces are very urbanized and are bordering the provincial city of Shanghai. Their study enables us to take into account negative externalities which can arise from an intense urban concentration. On the contrary, in Anhui province, the urbanization rate only reached 38.7% in 2007 and some rural counties still remain remote. Therefore, our sample is composed of rural counties sufficiently heterogeneous in terms of proximity-remoteness to the cities to carry out our study. Figure 1 represents the county-level divisions of the three provinces studied.

[Figure 1 here]

[9] All the necessary indicators are available from 2002 to 2007.

[10] The more dynamic rural areas were precisely those which enjoyed a change in administrative status; most of them became county-level cities (Chan, Henderson and Tsui, 2008). According to the data on the administrative divisions of these three provinces (See appendix A), Anhui did not experience any administrative change between 2002 and 2007. We count two administrative changes in Jiangsu province : Yandu county became a district of Yancheng city and Suyu county a district of Suqian city between 2003 and 2004. As for Zhejiang, two districts appeared during our sample period but the number of rural counties remains stable; thus, these new districts probably arose from the transformation of a share of a rural county into an urban district. As very few administrative changes occured between 2002 and 2007 in the provinces studied, it should not be a source of bias.

[11] Data is from the China Statistical Yearbook, 2008

3.2. Variables of interest

We want to assess if cities stimulate the technical efficiency level of their neighboring rural areas. As we said in the introduction, cities are either cities at the county-level or the urban districts under cities at the prefectoral and provincial levels (Shanghai). Cities of the surrounding provinces (Shandong, Henan, Hubei, Jiangxi and Fujian) do not appear on the previous map. However, they are taken into account in the calculation of the variables of interest.

To answer our two questions, we create a set of indicators. First of all, we want to estimate if counties close to cities are more efficient than remote ones. To answer this question, we create several indicators of proximity (or remoteness) of the counties. First, we use a simple measure of remoteness: the distance in kilometers from the rural county to the nearest city[12] (Partridge and Rickman, 2008). Second, we use a measure of proximity: the number of cities located at less than 85 kilometers from the county. The threshold of 85 km was chosen so that each county interacts at least with one city. However, to be sure that the results do not depend on the threshold chosen, we use other cut-off values. As a result, our third indicator of interest is the number of cities located at less than 120 kilometers from the county (this threshold ensures that each county interacts at least with one prefectoral city). Our fourth indicator is the number of cities located at less than 70 kilometers from the county.

Secondly, we want to assess if different types of cities affect counties in a different way. We take into account two characteristics of the cities : their size (Fafchamps and Wahba, 2006; Partridge and Rickman, 2008) and their economic structure (Benziger, 1996). We include two indicators of the size of the nearest city: the gross domestic product and the population of the nearest city. Then, to test if city size matters, we include successively one of these measures of the nearest city size together with the distance between the county and the nearest city. Regarding the economic structure of the city, we also create two indicators. The first one is the share of the primary sector in the GDP of the nearest

[12]Distance is calculated using latitude and longitude of each county and city. Data available on the U.S. Geological Survey web site : http://www.usgs.gov/.

city. The second one is the share of industry in the GDP of the nearest city. Then, to test if the economic structure of the city matters, we include successively one of these measures of the economic structure of the nearest city together with the distance between the county and the city[13].

Table 2 summarizes the different indicators used to measure urban proximity and to take into account the type of the city.

[Table 2 here]

4. Methodology

4.1. Stochastic production frontier

Two broad types of methodologies exist to study technical efficiency: Data Envelopment Analysis (DEA) and stochastic frontiers. If both methods have their own merits, the stochastic frontier method is usually considered as the best one to study agriculture[14].

Unlike the standard production function, the stochastic production frontier relaxes the assumption that all the producers are fully efficient. The stochastic production frontier model (Aigner, Lovell and Schmidt, 1977; Meeusen and van den Broeck, 1977) takes the following form:

$$\ln y_{it} = \beta_0 + \sum_{k=1} \beta_k \cdot \ln x_{kit} + \varepsilon_{it}$$

The error term ε_{it} is composed of two parts:

$$\varepsilon_{it} = v_{it} - u_{it}$$

where i refers to the county and t to the year. The dependant variable, y_{it}, is the output which is a function of a vector of k inputs (x_{kit}) and of a vector of unknown parameters to be estimated (β_k). The error term ε_{it} is composed of two parts: a traditional symmetric error component (v_{it}) and an inefficiency term (u_{it}). On the one hand, v_{it} is assumed to be

[13]Data on cities is from the China City Statistical Yearbooks (2003-2008).

[14]The DEA method does not account for noise and shocks (such as climatic shocks) and considers them as inefficiency (Coelli et al., 2005). The inherent stochastic nature of agriculture leads us to use the stochastic production frontier model.

iid and to follow a normal distribution centered at zero $[N(0, \sigma_v^2)]$. It is also assumed to be independent of the inefficiency term. On the other hand, u_{it} is a non-negative random variable. This component reflects the lack of ability of the producer to reach the maximum output it could produce. Indeed, the production frontier represents the maximum output that can be produced given the inputs and the technology. Then, if $u_{it} = 0$, county i is fully efficient and its effective level of production equals the maximum potential output. However, if u_{it} is positive, then, county i is technically inefficient as its effective level of production is inferior than the maximum output it could produce. The technical efficiency score of county i at year t is given by:

$$TE_{it} = e(-\hat{u}_{it})$$

Technical efficiency corresponds to the ratio of the effective output of county i relative to the output that would be produced by a fully efficient county. Then, technical efficiency scores take a value between zero and one.

In this study, we do not only want to estimate the inefficiency component but we are also interested in explaining it. More specifically, we want to assess if urban proximity affects technical efficiency. To do that, we estimate the model for inefficiency effects in a stochastic frontier production function (Battese and Coelli, 1995)[15]. This model is composed of two equations:

$$\ln y_{it} = \beta_0 + \sum_{k=1} \beta_k \cdot \ln x_{kit} + v_{it} - u_{it} \tag{1}$$

$$u_{it} = \delta_0 + \sum_{m=1} \delta_m \cdot \ln z_{mit} + w_{it} \tag{2}$$

Equation (1) is the production frontier and equation (2) is the inefficiency effects equa-

[15]This model in one stage is preferable to the two-stage approach. Indeed, the two-stage approach first estimates a stochastic production frontier in order to predict the technical inefficiency effects assuming that these effects are identically distributed. In a second stage, the predicted inefficiency effects are regressed on a set of explanatory variables which contradicts the assumption of identically distributed inefficiency effects made in the first stage (Battese and Coelli, 1995).

tion[16]. The second equation enables us to identify the determinants of technical inefficiency. Indeed, the technical inefficiency effects, u_{it}, are assumed to be a function of a set of explanatory variables (z_{mit}) and of a vector of unknown parameters (δ_m) to be estimated. The parameters of equations (4) and (5) are simultaneously estimated by the maximum likelihood. The likelihood function is expressed in terms of the variance parameters $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \sigma_u^2/\sigma^2$. Note that σ^2 must be positive and γ, which represents the share of inefficiency term in the variance of the composed error term, must lie between 0 and 1.

4.2. Empirical Model

To test if urban proximity affects technical efficiency we follow Nehring et al. (2006) by introducing a measure of urban proximity among the determinants of technical efficiency. The stochastic approach forces us to choose a specification for the production frontier. Although it imposes restrictions on the technology, we estimate a Cobb-Douglas function which does not suffer from multicolinearity problems contrary to flexible functional forms, such as the translog function (Hassine and Kandil, 2009; Mayen, Balagtas and Alexander, 2010). We estimate simultaneously the two following equations with the maximum likelihood using *Frontier 4.1*:

$$\ln y_{it} = \beta_0 + \sum_{k=1}^{4} \beta_k \cdot \ln x_{kit} + \sum_{p \neq k} \beta_p \cdot prov_p + \beta_7 \cdot trend + v_{it} - u_{it} \tag{3}$$

$$u_{it} = \delta_0 + \delta_1 \cdot \ln prox_{it} + \delta_2 \cdot \ln type_{it} + \sum_{m=3}^{5} \delta_m \cdot \ln z_{mit} + \sum_{p \neq m} \delta_p \cdot prov_p + \delta_8 \cdot trend \tag{4}$$

where i refers to the county, p to the province, k to the input and t to the year.

In the estimated model, we identify two different categories of variables: the production frontier variables (equation (3)) and the inefficiency variables (equation (4)). First, with regard to the production frontier variables, the dependent variable, y_{it}, and the inputs,

[16] The inefficiency components, u_{it}, are assumed to be independently (but not identically) distributed as truncations at zero of the normal distribution with mean ($z_{it}\delta$) and variance (${\sigma_u}^2$).

x_{it}, are the variables currently introduced in the literature on agricultural productivity. We use the logarithm of the gross output value of farming in constant prices as dependent variable. We consider two traditional inputs (labor and land) and two modern inputs (chemical fertilizers and machinery)[17]. We also introduce provincial fixed-effects ($prov_p$) to control for agro-climatic conditions (Alvarez and del Corral, 2009; Mayen, Balagtas and Alexander, 2010) and a time trend to take into account technical change. Second, regarding the inefficiency effects equation, we assume that inefficiency depends on the level of education, health and loan (z_{mit}) of the county (Liu and Zhang, 2000). We also introduce provincial dummies ($prov_p$) and allow inefficiency to vary over time by introducing a time trend. Last, but not least, we test if technical inefficiency depends on urban proximity ($prox_{it}$) and on the kind of city ($type_{it}$) the county is close to. As explained in the Section 3.2., different measures of urban proximity and of the city type are used to ensure robustness. The precise definitions and measures of all the variables are provided in appendices B and C.

5. Results

5.1. Does urban proximity enhance technical efficiency?

[Table 3 here]

First of all, we estimate if proximity to cities enhances technical efficiency without taking into account the characteristics of the cities. Table 3 presents estimates of the inefficiency effects in the production frontier model. The estimates of the production frontier are reported in the first part of the Table. On the one hand, the estimated elasticity for land is the highest which is coherent with the fact that China is a land-scarce country. On the other hand, the coefficient associated with machinery is insignificant in all regressions. This is not surprising as in China labor is abundant and so, we expect mechanical technologies (or labor-saving technologies) to be insignificant. Third, we find decreasing returns to scale, estimated to be from 0.827 to 0.851, which is very similar

[17] Although it is important to introduce indicators of input quality (Craig, Pardey and Roseboom, 1997), we do not introduce any variable to control for quality because we do not have such data.

to the values estimated by Chen, Huffman and Rozelle (2009). Finally, the coefficient associated with the time trend is positive and very significant. According to our results, Chinese agriculture benefits from a rate of technical progress of about 6% per year. The rate of technical change estimated is high but it should not be a surprise considering that the sample is composed of Jiangsu, Zhejiang and Anhui provinces. Besides, according to the calculations by Chen et al. (2008), Jiangsu and Zhejiang are just after Shanghai in terms of agricultural technical progress.

The second part of Table 3 is of particular interest as it gives the results of the estimation of the inefficiency model. On the one hand, the estimated variance parameters are significant and the parameter γ is close to one. This confirms that inefficiency does exist in Chinese agriculture. Given the value of the average efficiency level, the effective level of production of counties only represents about 80% of the maximum output they could produce. On the other hand, several studies warn that agricultural efficiency was deteriorating in China between the 1980s' and 1900s' (Kalirajan, Obwona and Zhao, 1996; Mao and Koo, 1997; Chen et al., 2008). However, we do not find any evidence of a decrease in technical efficiency over the period 2002-2007 as the time trend is insignificant. Regarding the determinants of technical inefficiency, it seems that counties with better health infrastructures are significantly more efficient. However, we do not find any effect relating to education. One surprising result is that loans increase inefficiency. This could be due to the fact that loans raise investment in new technologies. And, a fast technical change could coincide with a deterioration in technical efficiency when farmers do not have the time to assimilate new technologies (Mao and Koo, 1997). When it comes to our variable of interest, it appears in all regressions that being close to a city, whatever its size or its economic structure, raises technical efficiency. Indeed, the further a county is from its nearest city, the less efficient it is (estimation 1). In addition, the efficiency level increases with the number of neighboring cities (estimations 2-4). Then, being close to a city has a positive impact on technical efficiency and the best would be to be connected to several cities.

5.2. Do all the cities exert the same impact?

If being close to a city increases technical efficiency, do all the cities have the same impact on counties? Indeed, two cities being as close to one county may affect it in different ways according to their characteristics. That is why, we now test if cities have a different impact on counties according to their size or their economic structure. Table 4 gives the results of the estimation. In each case we introduce the distance in kilometers between each county and the nearest city in order to control for distance. In addition, we successively introduce an indicator of the size or of the economic structure of this city. Then, we test if, for cities located at the same distance from a county, bigger and more industrialized cities will enhance more (or less) the efficiency level of the county. The first interesting result is that technical efficiency decreases with city size. Thus, if being near a city enhances technical efficiency, it is better however to be near a small city. This result probably arises from the fact that bigger cities offer more non-agricultural employment opportunities which can drain neighboring rural areas of their most efficient workers. Second, the economic structure of the nearest city also matters. It would be better, in terms of technical efficiency, to be located near a city whose primary sector accounts for a large share of its GDP. The first result confirms the conclusion of Benziger (1996); on the contrary, the second one contradicts it. Indeed, the author also finds that proximity to smaller cities enhance agricultural productivity in Hebei. However, Benziger concludes that more industrialized cities stimulate agricultural productivity and the use of more modern inputs. The discrepancy between the results can be explained by at least two reasons. First, the two studies do not look at the same component of productivity. Indeed, Benziger focused on technical change and there is a high probability that industrialization raises the use of modern inputs. On the contrary, the present study is devoted to technical efficiency and as highlighted in Section 2., there is no reason *a priori* for heavily industrialized cities to have a positive impact on technical efficiency. Moreover, Benziger carried out his study in the 1980s' when China was much less industrialized than today. It is possible that 20 years ago, negative externalities arising from an intense industrialization had not yet occured. Besides, according to the more recent study of Monchuck, Chen and Bonaparte (2010), heavily industrialized counties have a less efficient agricultural sector than others.

[Table 4 here]

5.3. Discussion

To our knowledge, this study is the first to estimate the effect of urban proximity on agricultural technical efficiency in China. We find that being close to a city increases technical efficiency. This result is contrary to the conclusion of Nehring et al. (2006) according to which urban proximity negatively affects farmers' technical efficiency level in the US. However, their study is carried out on a sample of farmers in the Corn Belt, the production context of which is very different from the Chinese one. Therefore, we do not expect urban proximity to impact technical efficiency by the same transmission channels. For example, if urban proximity most likely enhances efficiency in China giving farmers more opportunities to become rich, in the Corn Belt, this transmission channel should not be at work as even farmers in remote areas have the opportunity to become rich.

One possible shortcoming of this study however, is that we assume that remote counties and counties close to cities produce the same agricultural products, which could be misleading. Indeed, we assume that counties close to cities are more efficient thanks to the mechanisms highlighted in section 2 (urban market access, knowledge spillovers, competition for the use of land, Lewis effect). Nevertheless, their higher level of efficiency could also arise from the fact that the agricultural output they produce is less complicated to yield than those of the remote counties. To relax the assumption according to which all the counties produce the same type of agricultural output, we could estimate a production frontier either with several outputs or with only one type of output (grain or vegetables for example). Yet, the lack of disaggregated output data at the county-level prevents us from estimating these models. Another objection could be made regarding the direction of causality. It could indeed be argued that the most enterprising farmers settle close to cities in order to benefit from the urban market. In this case, the higher level of technical efficiency would not stem from urban proximity but from differences in farmers characteristics. However, in China, it is very likely that the causality runs from urban proximity to agricultural productivity. Indeed, farmlands are allocated by the authorities to farmers, according to their birth place, and nothing indicates that the most enterprising farmers are given the land close to urban centers. Moreover in China, the land market is under-developed and migration from one rural area to another rural area is very low[18] so that farmer migration is quasi non-existent. As a result, the location of Chinese farmers should be exogeneous to their ability to produce.

6. Conclusion

Agricultural productivity growth is a real challenge in China today. According to previous studies, not all the components of productivity have seen the same evolution. More precisely, if technological change seems to be the strength of Chinese agriculture, technical efficiency would be its weakness. That is why, efforts should focus on technical efficiency. If many of its determinants have been investigated, to our knowledge, no-one has studied the impact of urban proximity. This article contributes to the literature on the determinants of technical efficiency studying if cities enhance the technical efficiency level of their neighboring rural areas.

Estimating the inefficiency effects model in a stochastic production frontier, we find that counties close to cities are significantly more efficient than remote ones. The second result is that the kind of city a county is close to matters. Being close to a small city stimulates technical efficiency. In the same way, being close to a city not heavily industrialized increases efficiency. According to our results, technical efficiency is still quite low in China. One way to raise efficiency could be to strengthen ties between rural and urban areas. Indeed, it seems that in remote counties, farmers lack incentives as they have few opportunities to get rich because of their poor access to urban markets. Giving them the possibilities to become rich would probably raise their technical efficiency level. This would also enable them to benefit from knowledge spillovers and from more opportunities to work out of agriculture which could reduce the agricultural labor surplus. In addition, the best solution would be to foster interactions between counties and small, not too heav-

[18] According to Chinese Household Income Project data (2007), more than 90% of migrant rural laborers leave their local countryside to work in towns or cities.

ily industrialized cities. In terms of urban planning, the optimal solution seems to consist in fostering the development of a network of small-medium sized cities, scattered accross the territory.

Our results also suggest that urban proximity must be measured with caution. Several works use an index of population weighted by the inverse of the distance (see for example Soule, Tegene and Wiebe (2000) and Fafchamps and Wahba (2006)) on conservation practices in agriculture). Given the indicators used, these studies assume that proximity to the city and city size affect counties in the same direction. In fact, it appears that one cannot *a priori* assume that both proximity and city size have a positive (negative) impact. Thus, to study the effect of urban proximity, it would perhaps be better to use on the one hand proximity measures (distances in km) and on the other hand, mass variables (city size).

Finally, the positive effect of urban proximity estimated here should not be over-interpreted. Indeed, this paper focuses on technical efficiency. If previous studies, as this current one, find that urban proximity has a positive impact on *quantitative indicators* (output, productivity and its components), what is its effect on more *qualitative indicators*? It could be argued for example that urban proximity favors the emergence of intensive agriculture at the expense of conservation agriculture. As a result, future research still have to assess the effect of urban proximity on the whole agricultural sector and more particularly on "agricultural quality".

Table 1: Effect of urban proximity on agricultural technical efficiency

Transmission channels	**Expected effect**
1. Opportunity to become rich : incentive to intensify labor effort	+
2. Competition for the use of land and risk of being relocated	+
3. Knowledge diffusion : better control on the environment	+
4. Job opportunities out of agriculture	
4.1. Reduce labor surplus (Lewis effect)	+
4.2. Departure of the most efficient workers	-

Table 2: Variables of interest

Variables		Obs	Mean	Std. Dev.	Min	Max
Urban proximity						
Distance to the nearest city	Remoteness	702	38.79	15.31	12.42	84.75
Number of cities at less than 85 km	Proximity	702	4.42	2.63	1	14
Number of cities at less than 120 km	Proximity	702	9.05	4.36	2	23
Number of cities at less than 70 km	Proximity	702	2.91	1.8	0	10
City type						
Gross Domestic Product	City size	702	154.46	134.15	21.58	900.3
Population	City size	702	97.11	56.52	26	276.52
Share of primary industry	Economic structure	702	12.72	9.28	0.37	41.13
Share of secondary industry	Economic structure	702	49.14	10.35	23.82	76.00

Table 3: Proximity and technical efficiency

	(1)	(2)	(3)	(4)
Production Frontier Model				
Constant	-0.412***	-0.436***	-0.472***	-0.427***
	(0.113)	(0.115)	(0.107)	(0.109)
Land	0.460***	0.441***	0.414***	0.447***
	(0.033)	(0.034)	(0.035)	(0.034)
Labor	0.199***	0.220***	0.235***	0.205***
	(0.028)	(0.028)	(0.029)	(0.027)
Machinery	-0.001	0.010	0.033	0.013
	(0.022)	(0.023)	(0.024)	(0.022)
Fertilizer	0.192***	0.185***	0.178***	0.188***
	(0.026)	(0.025)	(0.026)	(0.026)
Jiangsu	0.286***	0.308***	0.331***	0.304***
	(0.033)	(0.042)	(0.043)	(0.036)
Zhejiang	0.720***	0.748***	0.722***	0.707***
	(0.068)	(0.066)	(0.063)	(0.067)
Trend	0.061***	0.061***	0.063***	0.061***
	(0.008)	(0.007)	(0.007)	(0.008)
Inefficiency effects model				
Constant	-5.783***	-3.729***	-2.976**	-5.254***
	(1.667)	(1.378)	(1.317)	(1.522)
Distance to nearest city	0.230***			
	(0.099)			
Number of contacts (85km)		-0.351***		
		(0.109)		
Number of contacts (120km)			-0.606***	
			(0.157)	
Number of contacts (70km)				-0.286***
				(0.107)
Education	0.009	0.173	0.269	0.061
	(0.254)	(0.349)	(0.461)	(0.260)
Health	-0.974***	-0.877***	-0.921***	-1.117***
	(0.298)	(0.278)	(0.271)	(0.335)
Loan	0.485***	0.490***	0.493***	0.592***
	(0.165)	(0.179)	(0.169)	(0.193)
Jiangsu	-0.653	-0.424	-0.334	-0.486
	(0.416)	(0.679)	(0.710)	(0.336)
Zhejiang	1.059***	1.192***	1.332***	1.133***
	(0.340)	(0.447)	(0.441)	(0.337)
Trend	-0.037	-0.037	-0.028	-0.046*
	(0.026)	(0.034)	(0.033)	(0.028)
σ^2	0.270***	0.248***	0.244***	0.287***
	(0.065)	(0.062)	(0.053)	(0.071)
γ	0.877***	0.875***	0.864***	0.886***
	(0.022)	(0.032)	(0.035)	(0.024)
Average efficiency level	0.807	0.798	0.810	0.809
Log-Likelihood	-39.253	-33.666	-27.521	-38.693
N	702	702	702	702

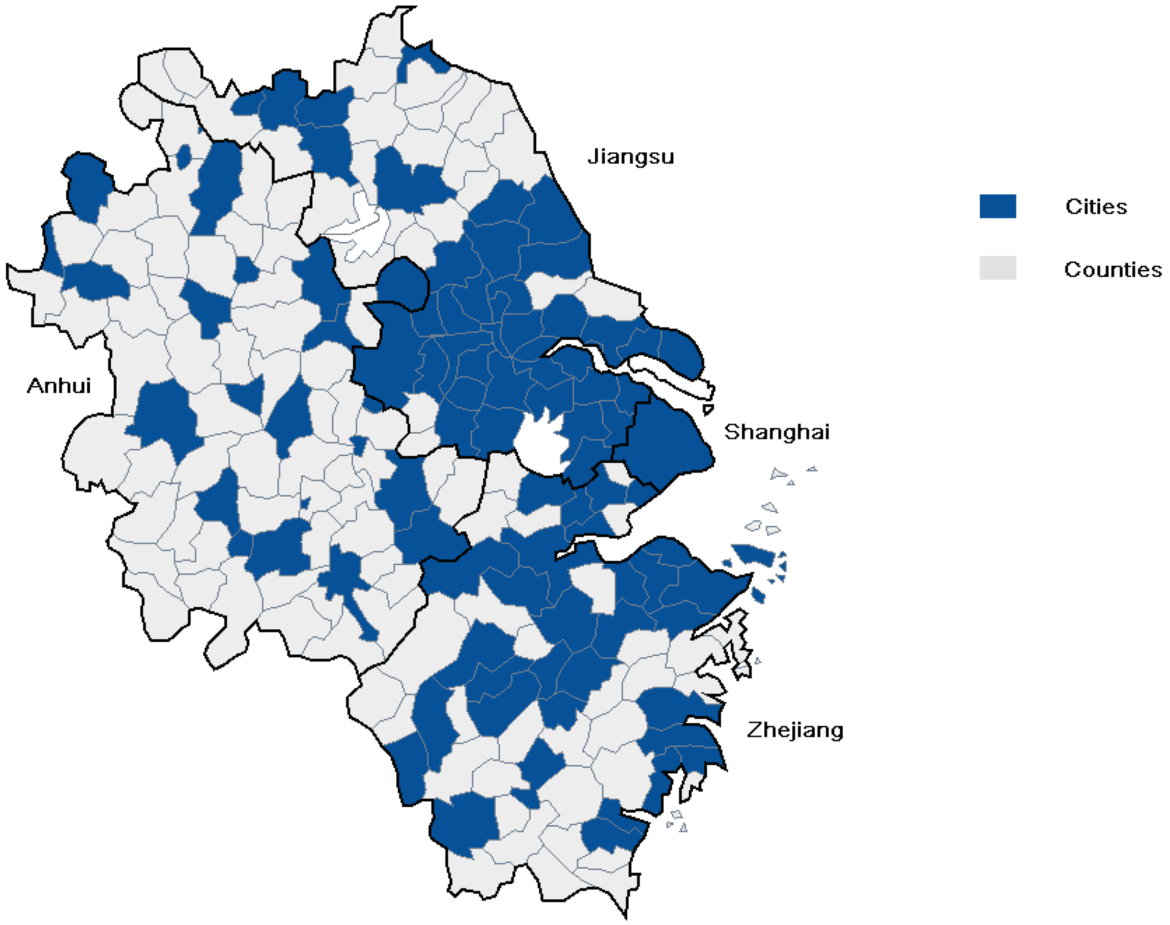
Note : *, **, *** indicate significance at the 10%, 5% and 1% levels respectively. Standard-errors in parenthesis. A negative sign in the inefficiency model means that the associated variable reduces technical inefficiency (and so, enhances efficiency).

Table 4: City type and technical efficiency

	(5)	(6)	(7)	(8)
Production Frontier Model				
Constant	-0.373***	-0.536***	-0.363***	-0.279**
	(0.132)	(0.100)	(0.133)	(0.127)
Land	0.440***	0.465***	0.451***	0.443***
	(0.034)	(0.033)	(0.035)	(0.034)
Labor	0.211***	0.238***	0.205***	0.187***
	(0.029)	(0.029)	(0.029)	(0.029)
Machinery	0.006	-0.005	-0.005	0.0004
	(0.023)	(0.021)	(0.023)	(0.022)
Fertilizer	0.189***	0.178***	0.197***	0.207***
	(0.026)	(0.026)	(0.026)	(0.026)
Jiangsu	0.296***	0.272***	0.292***	0.288***
	(0.043)	(0.042)	(0.042)	(0.040)
Zhejiang	0.737***	0.790***	0.743***	0.746***
	(0.068)	(0.070)	(0.069)	(0.063)
Trend	0.061***	0.064***	0.060***	0.057***
	(0.008)	(0.007)	(0.008)	(0.007)
Inefficiency effects model				
Constant	-5.563***	-6.528***	-4.415***	-7.091***
	(1.439)	(1.071)	(1.543)	(1.798)
Distance to nearest city	0.257**	0.178**	0.283**	0.257***
	(0.105)	(0.079)	(0.123)	(0.098)
City GDP	0.241***			
	(0.066)			
City Population		0.523***		
		(0.104)		
Share of primary industry			-0.118**	
			(0.055)	
Share of secondary industry				0.628***
				(0.232)
Education	-0.249	-0.209	-0.081	-0.256
	(0.268)	(0.208)	(0.281)	(0.230)
Health	-0.649***	-0.617***	-0.705***	-0.679***
	(0.166)	(0.097)	(0.264)	(0.166)
Loan	0.208*	0.227***	0.296*	0.300***
	(0.109)	(0.081)	(0.158)	(0.106)
Jiangsu	-0.531	-1.362	-0.379	-0.340
	(0.613)	(1.193)	(0.623)	(0.374)
Zhejiang	0.857***	1.144***	0.986**	0.651***
	(0.317)	(0.295)	(0.401)	(0.241)
Trend	-0.046	-0.021	-0.031	-0.034
	(0.029)	(0.026)	(0.029)	(0.026)
σ^2	0.214***	0.188***	0.235***	0.213***
	(0.049)	(0.028)	(0.063)	(0.042)
γ	0.861***	0.814***	0.874***	0.879***
	(0.035)	(0.037)	(0.032)	(0.028)
Average efficiency level	0.789	0.811	0.789	0.771
Log-Likelihood	-31.793	-22.454	-37.147	-36.198
N	702	702	702	702

Note : *, **, *** indicate significance at the 10%, 5% and 1% levels respectively. Standard-errors in parenthesis. A negative sign in the inefficiency model means that the associated variable reduces technical inefficiency (and so, enhances efficiency).

Figure 1: Cities and counties in Anhui, Jiangsu and Zhejiang provinces



Appendix A. Divisions of administrative areas in China in 2002 and 2007

	Number of regions at county-level	Number of county-level cities (xiàn-jishì)	Number of districts (shìxiaqu)	Number of rural counties (xiàn)
Year 2002:				
National Total	2860	381	830	1649
Jiangsu	106	27	52	27
Zhejiang	88	22	30	36
Anhui	105	5	44	56
Year 2007:				
National Total	2859	368	856	1635
Jiangsu	106	27	54	25
Zhejiang	90	22	32	36
Anhui	105	5	44	56

Note : data is from the China Statistical Yearbooks (2003 and 2008).

Appendix B. Definition of the variables

Variable	Definition	Unit
	Frontier variables	
Output	Gross output value of farming	Million yuan (constant prices)
Land	Cultivated area	1000 hectares
Labor	Agricultural labor	10,000 persons
Machinery	Total power of agricultural machinery	10,000 kW
Fertilizer	Consumption of chemical fertilizer	10,000 tons
	Inefficiency variables	
Distance to nearest city	Distance to nearest city	Kilometers
Number of contacts (85km)	Number of cities situated at less than 85 km from the county	Cities
Number of contacts (120km)	Number of cities situated at less than 120 km from the county	Cities
Number of contacts (70km)	Number of cities situated at less than 70 km from the county	Cities
City GDP	Gross domestic product of the nearest city	100 million yuan
City population	Population of the nearest city	10,000 persons
Share of primary industry	Share of primary industry in GDP of the nearest city	%
Share of secondary industry	Share of secondary industry in GDP of the nearest city	%
Education	Share of students enrolled in regular secondary schools in population	%
Health	Number of Beds in Hospitals and Sanitation Agencies	10,000 beds
Loan	Outstanding Loan of Financial Institutes at Year-end (constant prices)	100 million yuan

Appendix C. Descriptive statistics

	Obs	Mean	Std. Dev.	Min	Max
		Frontier Variables			
Output	702	11.15	8.16	0.05	46.08
Land	702	49.77	40.65	0.07	142.40
Labor	701	18.87	13.23	1.30	65.10
Machinery	702	43.08	36.18	2.51	223.04
Fertilizer	701	3.39	3.05	0.00	14.49
		Inefficiency variables			
Distance to nearest city	702	38.79	15.31	12.42	84.75
Number of contacts (85km)	702	4.42	2.63	1	14
Number of contacts (120km)	702	9.05	4.36	2	23
Number of contacts (70km)	702	2.91	1.80	0	10
City GDP	702	154.46	134.15	21.58	900.30
City population	702	97.11	56.52	26.00	276.52
Share of primary industry	702	12.72	9.28	0.37	41.13
Share of secondary industrustry	702	49.14	10.35	23.82	76.00
Education	702	6.37	1.37	3.06	9.78
Health	702	0.10	0.05	0.01	0.28
Loan	702	28.80	32.80	0	413.57